

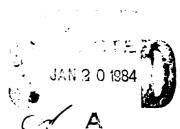
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POSITION DETERMINATION WITH LORAN-C TRIPLETS USING THE HEWLETT-PACKARD HP-75C, THE SHARP PC-1500 (TRS-80 PC-2) OR THE RADIO SHACK TRS-80 MODEL 100 PORTABLE COMPUTERS

by

Rex H. Shudde

September 1983

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Rear Admiral J. J. Ekelund Superintendent David A. Schrady Provost

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This report was prepared by:

REX H. SHUDDE, Associate Professor Department of Operations Research

Reviewed by:

Released by:

ALAN R. WASHBURN, Chairman

Department of Operations Research

WILLIAM M. TOLLES Dean of Research

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Loran-C Navigation	HP-75C	Radio Shack
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	TRS-80 Model 100	
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Rex H. Shudde

Naval Postgraduate School Monterey, California

September 1983

The programs in this report are for use within the Navy, and they are presented without representation or warranty of any kind.

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ABSTRACT

This report contains user instructions and program listings for a Loran-C position determination algorithm for use on an Hewlett-Packard HP-75C, a Sharp PC-1500 (Radio Shack TRS-80 PC-2) and a Radio Shack Model 100 portable computers.

I. INTRODUCTION

This report contains a Loran-C position determination program for each of the following portable computers: the Hewlett-Packard HP-75C, the Sharp PC-1500 (Radio Shack TRS-80 PC-2) and the Radio Shack) TRS-80 Model 100. These programs are part of a set that has been developed for a portable computer evaluation.

The Loran system is a radio aid to navigation which utilizes the principle of hyperbolic fixing. The locus of points for which the difference in arrival time of synchronized signals from a pair of transmitters is constant determines a hyperbolic line of positions. The intersection of two hyperbolic lines of position from two pairs of stations determines a hyperbolic fix. That two pairs of stations are required for a fix does not necessarily mean that there are four separate stations, for one station of one pair may be colocated with one station of the other pair forming a Loran triplet. Triplets may be joined "end-to-end" by station colocation to form a Loran chain. Loran chains are common on both the East and West coasts of the North American continent.

The present day Loran-C operates at 100-kHz and is in use in the Atlantic, Pacific and Mediterranean areas. The computational programs described herein can be used for position determination with Loran-C triplets. Further information on the history, development and operation of the Loran systems may be found in References 1 and 2. Details of the fixing algorithm can be found in Reference 3.

In the programs presented here, there are ten user options.

The computer display abbreviations for the option names and their definitions are listed below.

- 1. LORAN FIX. This fixing routine is the main program for calculating a LORAN-C fix from indicated time delays (ITDs).
- 2. ALTERNATE SOLN. The alternate solution routine will allow the second LORAN-C fix solution to be computed. This routine toggles an alternate solution flag so that on subsequent fixes Option 1 will calculate the alternate solution.
- 3. INPUT DEST LAT/LONG. This option is used to store the latitude and longitude of a destination.
- 4. HEAD & DIST TO DEST. This option is used to compute the heading and distance from the currect fix to the destination stored by Option 3.
- 5. PREDICT ITDs. This option may be used to predict the station ITDs that will be received at a given latitude and longitude.
- 6. TWO POINT HEAD & DIST. This option is similar to Option 4 except that it may be used to compute the heading and distance from any origin to any destination.
- 7. CALIBRATE. Given the latitude and longitude of a benchmark position and the indicated time delays from a LORAN-C triplet received at the benchmark position, the stored station data are modified so that the fix routine (or alternate solution routine) will compute the known position from the same time delays.

- 8. NEW STA. IDs. This option is used to load the two station pairs being received by requesting the group repetition interval (GRI) identifier.
- 9. ASF Corrections. When a portion of the propagation path lies over land, the additional secondary factor (ASF) should be included in the observed time delay if precision navigation is required. This option allows the user to input the ASF correction [Ref. 4, 5].
- A. STOP. This option will exit from the LORAN-C routine.

An additional HELP option (H) is available in the Hewlett-Packard HP-75C and Sharp PC-1500 (TRS-80 PC-2) computers. This option will review the ten options in the display. The Radio Shack TRS-80 Model 100 does not have this option because all ten options can be displayed simultaneously.

II. THE HEWLETT-PACKARD HP-75C.

HP-75C USER INSTRUCTIONS.

The options are labeled 1 through 9, A or H. The H (Help) option will review options 1 - 9 & A. Option 6 (TWO POINT HEAD & DIST) is a stand-alone option which may be used by itself. For LORAN fixing, Option 8 must be selected first to load the station GRI's. If Option 8 is not used, then any option requiring the GRI's will automatically enter Option 8 first. Option 1 (LORAN FIX) must be selected at least once before Option 2 (ALTERNATE SOLN) can be selected. Once the GRI's are loaded, any of the remaining options may be used at any time. When first run, the ASF Correction Factors are set to zero; if they are subsequently entered as non-zero values they will remain set until either changed manually, by selection of Option 9, or until the program is RUN once more. In all cases, South latitudes and East longitudes must be negative for input and will be labeled by a minus sign '-' on output. For ease of reference the options are listed by number rather than by sequence of selection.

	INSTRUCTION	DISPLAY	INPUT
Rui	n Program		Run "LORAN"
1.	LORAN FIX ITD for 1st GRI ITD for 2nd GRI Lat of fix Long of fix	NEXT OPTION (Help)? ITD FOR gri 1? ITD FOR gri 2? LAT = dd°mm'ss" LONG = ddd°mm'ss" NEXT OPTION (Help)?	l lst ITD [RTN] 2nd ITD [RTN] [RTN] [RTN]
2.	ALTERNATE SOLN Lat of fix Long of fix	LAT = dd°mm'ss" LONG = ddd°mm'ss" NEXT OPTION (Help)?	2 [RTN] [RTN]
3.	INPUT DEST LAT/LONG	DEST LAT dd.mmss? DEST LONG ddd.mmss? NEXT OPTION (Help)?	3 Lat of dest. [RTN] Long of dest. [RTN]
4.	HEAD & DIST TO DEST Heading to dest. Dist. to dest.	HEADING = ddomm'ss" DISTANCE = mmm.ff n.mi. NEXT OPTION (Help)?	4 [RTN] [RTN]

HP-75C USER INSTRUCTIONS (cont.)

	INSTRUCTION	DISPLAY	INPUT
5.	PREDICT ITDs 1st ITD 2nd ITD	LONG ddd.mmss? ITD FOR gri 1 = xxxxx.xx µs ITD FOR gri 2 = xxxxx.xx µs New Lat/Lon or Return to menu N	Lat [RTN] Long [RTN] [RTN] (RTN] repeats Option 5 goes to next line
6.	TWO POINT HEAD & DIS Heading to dest. Dist. to dest.	ORIGIN LAT dd.mmss? ORIGIN LONG ddd.mmss? DEST LAT dd.mmss? DEST LONG ddd.mmss? HEADING = ddomm'ss" DISTANCE = mmm.ff n.mi. NEXT OPTION (Help)?	6 Lat of origin [RTN] Long of origin [RTN] Lat of dest. [RTN] Long of dest. [RTN] [RTN] [RTN]
7.	CALIBRATE	LAT dd.mmss? LONG ddd.mmss? ITD FOR gri 1? ITD FOR gri 2? NEXT OPTION (Help)?	7 Lat of fix [RTN] Long of fix [RTN] 1st 17D [RTN] 2nd ITD [RTN]
8.	NEW STA. IDS	lst GRI? 2nd GRI? NEXT OPTION (Help)?	8 Sta. ID [RTN] Sta. ID [RTN]
9.	ASF Corrections	ASF FOR gri 1? ASF FOR gri 2? NEXT OPTION (Help)?	9 1st ASF [RTN] 2nd ASF [RTN]
Α.	STOP	,	А

You are sailing off of the coast of California. Your destination is Moss Landing at about 36°48'N and 121°47'W. Your present ITD from station pair GRI 9940W is 16019 and your ITD from station pair GRI 9940Y is 42585. What is your current position and what is the heading and distance from your current position to Moss Landing? We assume that the GRI's 9940W and 9940Y have not yet been loaded.

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)? DEST LAT dd.mmss? DEST LONG ddd.mmss?	3 36.48 [RTN] 121.47 [RTN]	Input destination. 36°48' 121°47'
NEXT OPTION (Help)? lst GRI? 2nd GRI?	8 9940W [RTN] 9940Y [RTN]	Input station ID's.
NEXT OPTION (Help)? ITD FOR 9940W? ITD FOR 9940Y?	1 16Ø19 42585	Compute a fix.
LAT = 39°14'19" LONG = 115°50'52"	[RTN] [RTN]	Latitude of fix. Longitude of fix.

This fix is in Nevada. There are always two solutions to the LORAN equations. The navigator must select the correct one.

NEXT OPTION (Help)?	2	Select alternate soln.
LAT = $35^{\circ}00'01"$	[RTN]	Latitude of fix.
LONG = $125^{\circ} 00'09"$	[RTN]	Longitude of fix.

This fix is in the Pacific. The navigator knows it is the correct fix because of his estimate of where he should be.

NEXT OPTION (Help)?	4	Find heading & distance to destination.
HEADING = 54°34'11" DISTANCE = 190.38 n.mi.	[RTN] [RTN]	Heading to Moss Landing. Distance to Moss Landing.
		-
NEXT OPTION (Help)?		Repeat with new option or press A to quit.

How far, and in what direction, is Corvallis, Oregon (44°34'N, 123°16'W) from Cupertino, California (37°19'N, 122°02'W)?

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)?	6	Two point distance and heading.
ORIGIN LAT dd.mmss?	37.19 [RTN]	37° 19'
ORIGIN LONG ddd.mmss?	122.02 [RTN]	122° Ø2 '
DEST LAT dd.mmss?	44.34 [RTN]	44°34'
DEST LONG ddd.mmss?	123.16 [RTN]	123°16'
HEADING = 353 02'59"	[RTN]	
DISTANCE = 438.32 n.mi.	[RTN]	

NEXT OPTION (Help)?

Repeat with new option or press A to quit.

HP-75C SAMPLE PROBLEM 3

Suppose that you want to know what ITD's you would expect to receive at 35° North, 125° West and at 36°27' North, 126°54' West from 9940W and 9940Y. To determine these ITD's, proceed as follows (assume that the GRI's have been loaded as in Sample Problem 1):

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)? LAT dd.mmss? LONG ddd.mmss? ITD FOR 9940W = 16019.35 μs ITD FOR 9940Y = 42584.71 μs New Lat/Lon or		Predict ITD's. 35° 125°
Return to menu? LAT dd.mmss? LONG ddd.mmss? ITD FOR 9940W = 15572.32 µs ITD FOR 9940Y = 43006.15 µs New Lat/Lon or Return to menu?	N 36.27 [RTN] 126.54 [RTN] [RTN] [RTN]	36° 27' 126° 54'

NEXT OPTION (Help)?

Repeat with new option or press A to quit.

Suppose you are receiving an ITD of 16308 from 9940W and 42800 from 9940Y. These ITD's would tell you that your location is 36°47'55"N and 121°47'11"W. However, you know that your position is benchmarked to be at 36°47'36"N and 121°46'58"W, and you wish to calibrate your HP-75C so that the ITD's of 16308 and 42800 will give you the latter fix instead of the former. Proceed as follows (assume the GRI's have been loaded as in Sample Problem 1):

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)?	7	Calibrate.
LAT dd.mmss?	36.4736 [RTN]	36°47'36"
LONG ddd.mmss?	121.4658 [RTN]	121°45'58"
ITD FOR 9940W?	16308 [RTN]	
ITD FOR 9940Y?	42800 [RTN]	

The station baselines have now been modified to achieve calibration. Now, reenter 16038 and 42800 into the fixing routine to test the calibration. Calibration does not modify the permanent station data stored in the HP-75C. The calibration remains effective until the GRI's are reloaded by Option 8. NOTE: The affect of calibration on the accuracy of fixes far removed from the benchmark has not been studied. The user should use the calibration option with caution.

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)?	1	Compute a fix.
ITD FOR 9940W?	16308 [RTN]	
ITD FOR 9940Y?	42800 [RTN]	
LAT = $36^{\circ}47'35"$	[RTN]	Lat of fix.
$LONG = 121^{\circ}46'59"$	[RTN]	Long of fix.

The small discrepancy between this fix and the benchmark is due to assumptions in the fixing algorithm. If higher precision is required, the ASF Correction factor may be used (see Sample Problem 5). Note that you may need to use the Alternate Solution Option 2 if the fix obtained above is near 38°52'57"N and 116°51'11'W.

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)?		Repeat with new option or press A to quit.

Suppose you are receiving an ITD of 12153.31 microseconds from 9960W and 44451.83 microseconds from 9960Y. These ITD's would tell you that your location is 44°15'05"N and 67°25'23"W. Entering the ASF Correction Tables [Ref. 5,6] with these readings, the ASF Correction for GRI 9960W at 44°15'N and 67°25'W is 1.5 microseconds. Similiarly, the ASF Correction for GRI 9960Y at these coordinates is 2.7 microseconds. Enter these corrections into your HP-75C and recompute your position. (Load the GRI's 9960W and 9960Y using Option 8).

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)? ASF FOR 9960W? ASF FOR 9960Y?	9 1.5 [RTN] 2.7 [RTN]	ASF Correction.
NEXT OPTION (Help)? ITD FOR 9960W? ITD FOR 9940Y? LAT = 44°15'26" LONG = 67°26'26"	1 12153.31 [RTN] 44451.83 [RTN] [RTN]	Compute a fix.
NEXT OPTION (Help)?	(2.0)	Repeat with new option or press A to quit.

These ASF Corrections have been entered into the computer. The range of their validity must be checked with the ASF Correction tables and reentered if they change. NOTE: If you are using the ASF Correction Tables and if you wish to calibrate to a benchmark position, you should first enter the ASF Corrections for your benchmark and then use the calibration Option 7 (see Sample Problem 4).

HP-75C PROGRAM LISTING

10 REM LORAN-C ROUTINE. rev 07-08-83, 1330 HOURS 28 N9=15 8 REM N9=# OF M ASTER STATIONS 30 OPTION ANGLE RADIANS @ OPTION BASE 1 48 BEF FNR(X,M) = INT(M* X+.5)/# 50 C0=1/298.26 € A0=-1 € G1\$= · · 60 DEF FNP(T) = 129.0439 8/T-.40758+.00064576438* **70 BEF FNO(T)** = 2.7412979/1-.011402+.00032774624 80 DISP @ GOTO 120 98 C\$=KEY\$ # IF C\$=" TH 100 C\$=UPRC\$(C\$) @ FOF C =1 TO LEN(COS) @ IF CS=C OSIC.C3 THEN DISP @ RETU 110 NEXT C @ GOTO 90 120 DISP 'NEXT OPTION (;CHR\$(200);'elp)?' @ C0\$ =:1234567890H: @ GOSUE 9 130 ON C GOSUB 910,950,1 010,1040,1090,990,1200,1 90,1350,530,140 0 GOTO 1 20 140 DISP '1 - LORAN FIX' @ BISP '2 - ALTERNATE S OLN: @ BISP :3 - IMPUT D EST LAT/LONG' 150 DISP '4 - HEAD & DIS T TO DEST' @ BISP '5 - P REDICT ITDs. 160 DISP '6 - THO POINT HEAD & DIST' @ DISP '7 -CALIBRATE . 178 BISP '8 - NEW STA. 1 Ds' @ DISP '9 - ASF Corr ections' @ BISP 'A - STO

180 RETURN 182 REM OPT 8 185 IF G1\$().. THEN RETU 198 F8=1 9 N=1 9 INPUT . 15t GRI? - I\$ 200 GOSUB 380 0 GOSUB 39 0 0 IF F0=2 THEN 198 218 F0=1 @ N=2 @ INPUT . 2nd GRI? *, I\$ @ GOSUB 3 220 IF A\$=19\$ THEN GOSUB 470 ELSE 240 230 IF F0=1 THEN 250 248 GOSUB 398 8 IF F8=2 THEN 210 250 F1=1 0 F2=1 0 IF G1\$ =G2\$ THEN 300 260 IF P(1,1)=P(1,2) AND L(1.1)=L(1.2) THEN 310 270 F2=-1 @ IF P(1,1)=P/ 2,2) AND L(1,1)=L(2,2) T **HEN 310** 280 F1=-1 @ IF P(2.1)=P(2,2) AND L(2,1)=L(2,2) T HEN 310 290 F2=1 @ IF P(2,1)=P(1 .2) AND L(2,1)=L(1.2) TH EN 319 300 DISP TE. NO TRIPLET *,G1\$:* & *:G2\$ @ G0SUB 1370 @ GOTO 190 310 FOR I=1 TO 2 0 P1=P(1.1) @ L1=L(1.1) @ P2=P(2.1) @ L2=L(2.1) 320 DISP @ GOSUB 330 @ K EXT I θ G(1)= θ θ G(2)= θ **e** RETURN 330 GOSUB 650 0 B(1)=S0 **●** Z(1,1)=Z1 **●** Z(2,1)=Z2 340 T=21282,3593*S0 350 IF T>=537 THEN P=FMP (T) 360 IF T(537 THEN P=FNQ(T) 370 T(I)=T+P @ RETURN

380 L=LEN(1\$) @ A\$=1\$[1, L-1] @ B\$=[\$[L.L] @ B=NU M(B\$) B B\$=CHR\$(B-32+(B) 981) # RETURN 390 N8=1 @ RESTORE -400 REAB 19\$, NB, PB, LQ @ M\$= · · 410 FOR I=1 TO NO @ REAT Wes, B9(I), P1(I), L1(I) @ WS=WS&W@S @ MEXT I 428 IF 1988AS THEN 458 439 GDSUB 470 9 IF F0=2 **THEN 460** 448 RETURN 450 N8=N8+1 0 IF N8(=N9 THEN 488 460 DISP IS: 15 NOT CAT PLOCED" @ FR=2 @ GOSUB 1 370 @ RETURN 470 FOR I=1 TO NO 8 IF W \$[1,1]=P\$ THEN 490 480 NEXT I @ F0=2 @ RETU 490 IF H=1 THEN G1\$=!\$ 500 IF N=2 THEN G2\$=I\$ 510 B(N)=B9(1) 0 P(1,N)=FWA(RAB(FNH(P@))) @ L(1. N)=RAB(FNH(L0)) 520 P(2,N)=FNA(RAB(FNH(P 1(I)))) @ L(2,N)=RAD(FNH (L1(I))) @ RETURN 530 DISP @ PUT CHR\$(13) € END 548 REM BIR SOLN 550 Z8=SIN(Z1) @ Z9=COS(Z1) @ P8=SIN(P1) @ P9=C0 S(P1) @ M=-Z8+P9 @ C1=C0 eH @ C2=C0+(1-H+H)/4 568 B=(1-C2)*(1-C2-C1*M) @ P=C2+(1+C1+H/2)/D @ H =P9*Z9 570 S1=ANGLE(P8,N) @ 100= S8/B @ U=2*(S1-B8) @ H=1 -2*P*COS(U) @ V=COS(U+D9)

588 X=C2+C2+SIN(D0)+CDS(10+(2+V+V-1)) @ Y=2*P*V* M#SIH(DO) 590 52=D0+X-Y 0 58=SIN(S 2) @ \$9=COS(\$2) @ K=\$QP(Maff+(HaS9-P8#S8)^2) 600 P2=ATH((P8+S9+H+S8)/ K) 618 S3=RMGLE(P9+S9-P8+S8 *Z9,-\$8*Z8) 620 H=C1*(1-C2)*S2-C1*C2 *SR*COS(\$1+\$1-\$2) @ L2=L 1+53-H 638 Z2=ANGLE/-(N#59-P8#5 8),-M) @ PETURN 648 REM REVERSE SOLM 650 L3=L2-L1 @ P3=(P2-P1)/2 @ P4=(P1+P2)/2 660 P6=SIN(P3) @ P7=C0S(P3) @ P8=SIN(P4) @ P9=C0 S(P4) 670 H=P7*P7-P8*P8 @ L=P6 *P6+H*SIN(L3/2)^2 @ D0=2 *ASIN(SQR(L)) 680 U=2*P8*P8*P7*P7/(1-L) @ V=2*P6*P6*P9*P9/L @ X=U+V @ Y=U-V @ T=D@/SIN (R0) @ P=4*T*T 690 E=2*COS(BO) @ A=T+E @ C=T-(A-E)/2 @ N1=X*(A+ C+X) # B=B+B # HS=A*(B+E *Y) @ M3=#*X*Y 700 B2=C0+C0+(N1-H2+H3)/ 64 @ 31=C8+(T+X-Y)/4 @ S 0=(T-B1+B2)*SIN(B0) 710 N=32+T-(20+T-A)+X-(B +4)*Y 728 F=Y+Y-E*(4-X) @ G=C0 *(T/2+C8*M/64) @ Q=-F*G* TRH(L3)/4 730 L4=(L3+Q)/2 @ L8=SIN (L4) @ L9=C05(L4) 749 T1=RNGLE(P9+L8,P6+L9) @ T2=AMGLE(P8*L8,-P7*L 9)

750 T9=PI+PI @ Z1=HOD(T1 +T2,T9) @ Z2=MOD(T1-T2,T 9) @ RETURN 760 REM FIXING ROUTINE 770 A1=F1+SIN(A(1)) € B1 =COS(R(1))-COS(B(1)) @ (1=SIN(B(1)) 780 A2=F2+SIN(A(2)) @ B2 =COS(A(2))-COS(B(2)) @ C 2=SIH(B(2)) 790 E1=Z(1,1) @ IF F1=-1 THEN E1=Z(2,1) 800 E2=Z(1,2) 0 IF F2=-1 THEN E2=Z(2,2) 818 C=81*C2*COS(E2)-B2*C 1*COS(E1) @ S=B1*C2*SIN(E2)-B2+C1+SIN(F1) 828 K=B2+A1-B1+A2 @ R=SQ R(C+C+S+S) @ G=RNGLE(C,S 838 Z=G+R0+RCOS(K/R) 9 S @=RMGLE(C2+COS(Z-E2)+R2) R2) 840 IF F2=1 THEH P1=P(1. 2) @ L1=L(1,2) 850 IF F2=-1 THEN P1=P(2 ,2) € L1=L(2,2) 860 Z1=Z @ GOSUB 550 @ F B=P2 @ LB=L2 @ P=ATN(TAN (P0)/(1-C0)870 P=BEG(P) @ L=MOD(BEG (L0),360) 0 IF L>180 THE N L=L-360 880 PS=FND\$(P) @ LS=FND\$ (L) 898 BISP "LAT = ";P\$ @ G OSUB 1370 @ DISP "LONG = *:L\$ @ COSUB 1370 @ RET IRN 900 REM OPT 1 - COMPUTE FIX 910 GOSUB 185 @ FOR I=1 TO 2 @ G\$=G1\$ @ IF I=2 T HEN G\$=G2\$

920 DISP TITD FOR TIGS: @ IMPUT *? *; A @ A=A+G(I)-B(I)-T(I) @ IF ABS(A) (T(I) THEN 940 930 BISP "E. ITD NOT YAL ID FOR ";G\$ @ GOTO 920 940 A(I)=A/21295.8736 0 MEXT I @ GOSUB 770 @ RET 950 IF 90=1 THEN 90=-1 @ **GOTO 965** 960 AG=1 965 IF G1\$=" THEN 918 970 GOSUB 770 @ RETURN 988 REM 0PT 6 998 IMPUT "ORIGIN LAT do .mass? "; P @ IMPUT "OR! GIN LONG ddd.nass? ":L 1888 PR=FMQ(RQT(FNH(P))) @ LO=RAB(FWH(L)) @ GOSU B 1010 0 GOSUB 1040 0 RE TURN 1010 IMPUT "DEST LAT dd. mass? ": P @ IMPUT "DEST LONG ddg.mmss? "/L 1828 P5=FWA(RAB(FWH(P))) @ L5=RAD(FMH(L)) @ PETU 1030 REH OPT 4 1848 P1=P8 @ L1=L8 @ P2= P5 @ L2=L5 @ GOSUB 65@ 1050 Z=MOD(BEG(Z1), 360) @ Z\$=FND\$(Z) 1060 DISP "HEADING = ";Z \$ @ GOSUB 1370 @ BISP "B ISTANCE = ";FWR(3443.917 *S8,100); n.mi." 1070 COSUB 1370 @ RETURN 1000 REN OPT 5 1090 GOSUB 185 0 GOSUB 1 170 @ FOR K=1 TO 2 @ 19= T(K)+B(K)1100 P2=P(2,K) @ L2=L(2, K) @ GOSU8 650 @ I=3 @ G OSUB 348 @ 19=19+T(3)

1388 C#=" " # IF X(# THE 1110 P2=P(1,K) @ L2=L(1, N (\$="-" K) @ GOSUB 650 @ I=3 @ G 1318 X=R8S(X)+1/7288 @ X OSUB 348 @ 19=19-T(3) e=INT(X) e C\$=C\$&STP\$(X0 1128 IS=G1\$ @ IF K=2 THE) LCHR\$(1) N IS=G2\$ 1139 BISP "ITB FOR ": 1\$: 1320 X=60+(X-X0) 0 X0=1H " =";FNR(19,100);CHR\$(12 T(X) @ X\$=STR\$(100+X0) @):"5" @ GOSUB 1370 @ MEX C\$=C\$&X\$[2,3]&"'" 1338 X=68+(X-X8) 8 X8=IH TK T(X) # X\$=STR\$(188+X8) # 1140 DISP CHR\$(206); "ev FWB\$=C\$&X\$[2.3]&CHR\$(34 Lat/Lon or ";CHR\$(210);" eturn to menu?" @ C8s="N 1349 END DEF P" @ GOSUB 90 1350 GOSUB 185 @ DISP 'A 1150 IF C=1 THEN 1090 SF FOR ';G1\$: @ INPUT '? 1160 RETURN 1178 IMPUT "LAT dd.mmss? 1;6(1) -; PI & IMPUT -LONG ddd 1360 BISP ASF FOR G2\$; @ IMPUT 12 1: G(2) @ P .mass? "iLl 1189 P1=FMR(RAD(FMH(P1)) ETURN 1370 C4=KEY\$ @ IF C\$="") @ L1=RAB(FMH(L1)) @ RE THEN 1370 TUPN 1386 BISP & RETURN 1190 REM OPT 7 1200 COSUB 185 0 GOSUB 1 5000 BRTR 4990,2,16,4443 95,169.38312,"X",11000,2 170 @ FOR K=1 TO 2 @ I\$= G1\$ @ IF K=2 THEN I\$=G2\$ 0.144916,155.53097 1210 DISP *ITD FOR *: 1\$: 5616 BATA "Y",29880,28.2 @ IMPUT -? -: 19 @ I9=I 34177, 178, 17302 5020 DATA 5930,2,46,4827 9-D(K) 199,67.5537713,"X",11000 1220 P2=P(2,K) @ L2=L(2, K) @ GOSUB 650 @ I=3 @ G ,41.151193,69.583909 OSU8 348 @ 19=19-T(3) 5839 BATA "Y", 25888, 46, 4 63218,53,102816 1230 P2=P(1,K) @ L2=L(1, K) e cosub 650 e 1=3 e G 5048 BATA 5970,3,36.1105 797,-129,2027279,*W*,110 05UB 348 @ T(K)=19+T(3)+ 08,42,4437104,-143,43092 G(K) 1248 NEXT K @ RETURN 45 1250 DEF FNH(X) 5050 DATA "X",31900,35.0 223871 -- 126. 3226741 / "7" / 1268 S=SCH(X) @ X=RBS(X) @ H=[NT(X) @ V=FP(X)+18 **42000**, 26. 3624975, -128. **0**8 56445 8 @ FWH=S*((100*FP(V)/60 5060 MATA 5990,3,51.5758 +INT(V))/60+H) 78,122,228224,*X*,11980, 1270 END DEF 1288 DEF FNA(X) = ATH((1 55.2628851,131.1519648 5879 BATA "Y",27888,47.9 -C0)+TRN(X)) 34799,119,443953,*Z*,419 1298 DEF FND\$(X) 99,59.3629731,127.212994

3

5000 DATA 7930,3,59.5917 27,45,102747.*W*,11000.6 4.542658,23.552175 5090 DATA "X",21000,62.1 75964,7.8426538,"Z",4388 0.46.463218.53.102816 5100 BATA "+7930",3,24.1 707888,-153.5853232."X" 11889, 42, 4437184, -143, 43 89245 5110 BATA "Y",30000,26.3 624975,-128.0856445,*2*. 49000, 9, 3245789, -138, 095 5120 BATA 7960-2,63,1942 814,142,48319."X",11008. 57, 262021, 152, 2211225 5130 DATA "Y",26000,55.2 628851,131.1519648 5140 DATA 7970,4,62.1759 64.7.0426538,"N",26008,5 4.4829872,-8.1736312 5158 DATA "X",11000,68.3 89615,-14,2747,"Y",46999 ,64.542658,23.552175 5160 DATA "7",60000,70.5 45261 - 8 . 435869 5170 BATA 7980.4,30.5938 74,85,1009305,*W*,11000, 30,4333018,90,49436 5188 BATA "X",23868,26.3 155006,97.5000093,"Y",43 000,27.0158393,88.065342 5190 DATA "Z",59000,34.0 346081,77.5446654 5200 BATA 7990,3,38.5220 587,-16.4386159,"X",1100 0,35,3120787,-12,3130245 5210 DATA "Y", 29000, 48.5 82095,-27.520152,"Z",470 90,42.0336515,-3.1215512

5220 BATA 8970,3,39,5107 54,87.291214,"N",11000,3 0.593874,85,1009305 5230 BRTR "X",28000,42.4 250603,76,4933862,"Y",44 880,48.3649844,94.331846 5240 BRTA 9948,3,39,3396 621,118.495637 5258 BRTA "W",11889,47.0 34799,119.443953,"X",270 99, 38, 465699, 122, 2944529 5260 BRTR "Y",40000,35.1 91818, 114, 4817435 5270 BATA 9960,4,42,4250 603,76.4933862,"N",11000 **,46.4827199,67.5537713** 5288 BATA "X", 25888, 41.1 51193,69.583909, "Y", 3900 8,34.0346081,77.5446654 5290 BRTR "2",54000,39.5 10754-87.291214 5380 BRTR 9978,4,24,4803 597,-141.1930303, W-, 110 **60,24.1707888,-153.58**532 32 5310 DATA "X",30000,42.4 437104 - 143.4309245 - "Y" -55800, 26.3624975, -128.08 56445 5320 BATR "Z",75000,9.32 45789 -- 138 . 895497 5330 DATA 9990,3,57.0912 265,170.1506789,"X",1100 8,52,494484,-173,1848974 5340 DATA "Y", 29000, 65.1 448386,166.531255,*Z*,43 008,57.262021,152.221122

III. THE SHARP PC-1500 (RADIO SHACK TRS-80 PC-2).

PC-1500 (TRS-80 PC-2) USER INSTRUCTIONS.

The options are labeled I through 9, A or H. The H (Help) option will review options 1 - 9 & A. To step through the HELP menu, use the ENTER key. Option 6 (TWO POINT HEAD & DIST) is a stand-alone option which may be used by itself. For LORAN fixing, Option 8 must be selected first to load the station GRI's. If Option 8 is not used, then any option requiring the GRI's will automatically enter Option 8 first. Option 1 (LORAN FIX) must be selected at least once before Option 2 (ALTERNATE SOLN) can be selected. Once the GRI's are loaded, any of the remaining options may be used at any time. When first run, the ASF Correction Factors are set to zero; if they are subsequently entered as non-zero values they will remain set until either changed manually, by selection of Option 9, or until the program is RUN once more. In all cases, South latitudes and East longitudes must be negative for input and will be labeled by a minus sign '-' on output. For ease of reference the options are listed by number rather than by sequence of selection.

	INSTRUCTION	DISPLAY	INPUT
Rui	n Program		RUN.10
1.	LORAN FIX ITD for 1st GRI ITD for 2nd GRI Lat of fix Long of fix	NEXT OPTION (Help)? ITD FOR gri 1? ITD FOR gri 2? LAT = ddomm'ss" LONG = dddomm'ss" NEXT OPTION (Help)?	l lst ITD [ENTER] 2nd ITD [ENTER] [ENTER] [ENTER]
2.	ALTERNATE SOLN Lat of fix Long of fix	LAT = ddomm'ss" LONG = dddomm'ss" NEXT OPTION (Help)?	2 [ENTER] [ENTER]
3.	INPUT DEST LAT/LONG	DEST LAT dd.mmss? DEST LONG ddd.mmss? NEXT OPTION (Help)?	3 Lat of dest. [ENTER] Long of dest. [ENTER]
4.	HEAD & DIST TO DEST Heading to dest. Dist. to dest.	HEADING = ddomm'ss" DISTANCE = mmm.ff n.mi. NEXT OPTION (Help)?	4 [ENTER] [ENTER]

PC-1500 (TRS-80 PC-2) USER INSTRUCTIONS (cont.)

	INSTRUCTION	DISPLAY	INPUT					
5.	PREDICT ITDs 1st ITD 2nd ITD	LONG ddd.mmss? ITD FOR gri 1 =	Lat [ENTER] Long [ENTER] [ENTER] [ENTER] N repeats Option 5 R goes to next line					
6.	TWO POINT HEAD & DIS	ORIGIN LAT dd.mmss? ORIGIN LONG ddd.mmss? DEST LAT dd.mmss? DEST LONG ddd.mmss?	6 Lat of origin [ENTER] Long of origin [ENTER] Lat of dest. [ENTER] Long of dest. [ENTER]					
	Heading to dest. Dist. to dest.	HEADING = dd°mm'ss" DISTANCE = mmm.ff n.mi NEXT OPTION (Help)?	[ENTER]					
7.	CALIBRATE	LAT dd.mmss? LONG ddd.mmss? ITD FOR gri 1? ITD FOR gri 2? NEXT OPTION (Help)?	7 Lat of fix [ENTER] Long of fix [ENTER] 1st ITD [ENTER] 2nd ITD [ENTER]					
8.	NEW STA. IDs	lst GRI? 2nd GRI? NEXT OPTION (Help)?	8 Sta. ID [ENTER] Sta. ID [ENTER]					
9.	ASF Corrections	ASF FOR gri 1? ASF FOR gri 2? NEXT OPTION (Help)?	9 lst ASF [ENTER] 2nd ASF [ENTER]					
Α.	STOP		Α					

>

You are sailing off of the coast of California. Your destination is Moss Landing at about 36°48'N and 121°47'W. Your present ITD from station pair GRI 9940W is 16019 and your ITD from station pair GRI 9940Y is 42585. What is your current position and what is the heading and distance from your current position to Moss Landing? We assume that the GRI's 9940W and 9940Y have not yet been loaded.

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)? DEST LAT dd.mmss? DEST LONG ddd.mmss?	3 36.48 [ENTER] 121.47 [ENTER]	Input destination. 36°48' 121°47'
NEXT OPTION (Help)? lst GRI? 2nd GRI?	8 9940W [ENTER] 9940Y [ENTER]	Input station ID's.
NEXT OPTION (Help)? ITD FOR 9940W? ITD FOR 9940Y?	1 16019 42585	Compute a fix.
LAT = 39 14 19 LONG = 115 50 52	[ENTER] [ENTER]	Latitude of fix. Longitude of fix.

This fix is in Nevada. There are always two solutions to the LORAN equations. The navigator must select the correct one.

NEXT OPTION (Help)?	2	Select alternate soln.
LAT = 35 00 01	[ENTER]	Latitude of fix.
LONG = 125 00 09	[ENTER]	Longitude of fix.

This fix is in the Pacific. The navigator knows it is the correct fix because of his estimate of where he should be.

NEXT OPTION (Help)?	4	Find heading & distance to destination.				
HEADING = 54 34 11 DISTANCE = 190.38 n.mi.	[ENTER] [ENTER]	Heading to Moss Landing. Distance to Moss Landing.				
NEXT OPTION (Help)?		Repeat with new option or press A to quit.				

How far, and in what direction, is Corvallis, Oregon (44°34'N, 123°16'W) from Cupertino, California (37°19'N, 122°02'W)?

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)?	6	Two point distance and heading.
ORIGIN LAT dd.mmss?	37.19 [ENTER]	37°19'
ORIGIN LONG ddd.mmss?	122.02 [ENTER]	122°02'
DEST LAT dd.mmss?	44.34 [ENTER]	44°34'
DEST LONG ddd.mmss?	123.16 [ENTER]	123°16'
HEADING = 353	[ENTER]	
DISTANCE = 438.32 n.mi.	[ENTER]	

NEXT OPTION (Help)?

Repeat with new option or press A to quit.

PC-1500 (TRS-80 PC-2) SAMPLE PROBLEM 3

Suppose that you want to know what ITD's you would expect to receive at 35° North, 125° West and at 36°27' North, 126°54' West from 9940W and 9940Y. To determine these ITD's, proceed as follows (assume that the GRI's have been loaded as in Sample Problem 1):

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)? LAT dd.mmss? LONG ddd.mmss? ITD FOR 9940W = 16019.35 ITD FOR 9940Y = 42584.71 New Lat/Lon or	5 35 [ENTER] 125 [ENTER] [ENTER] [ENTER]	Predict ITD's. 35° 125°
Return to menu? LAT dd.mmss? LONG ddd.mmss? ITD FOR 9940W = 15572.32 ITD FOR 9940Y = 43006.15 New Lat/Lon or	N 36.27 [ENTER] 126.54 [ENTER] [ENTER] [ENTER]	36° 27 ' 126° 54 '
Return to menu?	R	

NEXT OPTION (Help)?

Repeat with new option or press A to quit.

Suppose you are receiving an ITD of 16308 from 9940W and 42800 from 9940Y. These ITD's would tell you that your location is 36°47'55"N and 121°47'11"W. However, you know that your position is benchmarked to be at 36°47'36"N and 121°46'58"W, and you wish to calibrate your PC-1500 so that the ITD's of 16308 and 42800 will give you the latter fix instead of the former. Proceed as follows (assume the GRI's have been loaded as in Sample Problem 1):

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)?	7	Calibrate.
LAT dd.mmss?	36.4736 [ENTER]	36°47'36"
LONG ddd.mmss?	121.4658 [ENTER]	121°45'58 "
ITD FOR 9940W?	16308 [ENTER]	
ITD FOR 9940Y?	42800 [ENTER]	

The station baselines have now been modified to achieve calibration. Now, reenter 16038 and 42800 into the fixing routine to test the calibration. Calibration does not modify the permanent station data stored in the PC-1500. The calibration remains effective until the GRI's are reloaded by Option 8. NOTE: The affect of calibration on the accuracy of fixes far removed from the benchmark has not been studied. The user should use the calibration option with caution.

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)? ITD FOR 9940W? ITD FOR 9940Y?	1 16308 [ENTER] 42800 [ENTER]	Compute a fix.
LAT = 36 47 35	[ENTER]	Lat of fix.
LONG = 121 46 59	[ENTER]	Long of fix.

The small discrepancy between this fix and the benchmark is due to assumptions in the fixing algorithm. If higher precision is required, the ASF Correction he used (see Sample

COMMENTS

Laci	COL	may	рe	usea	. (S	ee	Sai	nbTe	e P	COD	Tem	5).	NO	ce	tna	τy	ou
may	nee	d to	us	e th	e A	lte	erna	ate	So.	lut	ion	Opt	ion	2	if	the	
fix	obt	aine	d a	bove	is	ne	ear	3 8	° 52	57	"N	and	116	51	'11	'W.	

DISPLAY CONTENTS USER RESPONSE

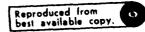
NEXT OPTION (Help)? Repeat with new option or press A to quit.

Suppose you are receiving an ITD of 12153.31 microseconds from 9960W and 44451.83 microseconds from 9960Y. These ITD's would tell you that your location is 44°15'05"N and 67°25'23"W. Entering the ASF Correction Tables [Ref. 5,6] with these readings, the ASF Correction for GRI 9960W at 44°15'N and 67°25'W is 1.5 microseconds. Similiarly, the ASF Correction for GRI 9960Y at these coordinates is 2.7 microseconds. Enter these corrections into your PC-1500 and recompute your position. (Load the GRI's 9960W and 9960Y using Option 8).

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
NEXT OPTION (Help)? ASF FOR 9960W? ASF FOR 9960Y?	9 1.5 [ENTER] 2.7 [ENTER]	ASF Correction.
NEXT OPTION (Help)? ITD FOR 9960W? ITD FOR 9940Y? LAT = 44 15 26 LONG = 67 26 26	1 12153.31 [ENTER] 44451.83 [ENTER] [ENTER] [ENTER]	Compute a fix.
NEXT OPTION (Help)?		Repeat with new option or press A to quit.

These ASF Corrections have been entered into the computer. The range of their validity must be checked with the ASF Correction tables and reentered if they change. NOTE: If you are using the ASF Correction Tables and if you wish to calibrate to a benchmark position, you should first enter the ASF Corrections for your benchmark and then use the calibration Option 7 (see Sample Problem 4).

10:REM LORAN-C R	140: PRINT '1 - LOR
OUTINE. Nev 06	AN FIX' PRINT
-23-83. 1 <i>7</i> 30 Н	'2 - ALTERNATE
DURS.	SOLN':PRINT "
20:N9=15:REM N9=	3 -INPUT DEST
# OF MASTER ST	LAT/LONG'
ATIONS	150: PRINT '4 - HEA
25:DIM W\$(4)*1,D9	D & DIST TO FI
(4),P1(4),L1(4	X': PRINT '5 -
), G\$(2)*6, D(2)	PREDICT ITDs"
	160: PRINT 16 - TWO
, P(2, 2), L(2, 2)	100. FRINI O - WO
,B(2),T(3), <i>Z</i> (2	POINT DIST &
,2),4(2)	HEAD : PRINT 17
26:DIM G(2)	- CALIBRATE
30: RADIAN : 00=1/2	178: PRINT 18 - NEW
SOLKHOIAN COFIZ	761- K.N. C - NEA
98.26:40=-1:RD	STA. ID:17 Print 19 - Asf
=PI /180:G1\$='	PRINT 19 - ASF
:GOTO 120	Connections'
40:X=INT (M*X+.5)	PRINT A - STO
	P: 0 0
∠M: RETURN	*
50:P=129.04398/T-	180:RETURN
.40758+.645764	185: IF G1\$<>' THEN
38E-3*T: RETURN	RETURN
60:P=2.7412979/T-	190:F0=1:N=1:INPUT
.011402+.32774	'1st GRI? ';!\$
624E-3*T	:PAUSE '
70:C\$=1NKEY\$: IF	200:COSUB 380:
C\$=" THEN 70	COSUB 390.1F F
80:C=ASC (C\$):C\$=	
	0-2THEN 190
CHR\$ (C-32*(C)	210:F0=1:N=2:INPUT
90))	"2nd GRI? ;1\$
90: FOR C=1TO LEN	:PAUSE ' :
(CØ\$): IF C\$=	GOSUB 380
MID\$ (CØ\$, C, 1)	220: IF A\$=19\$THEN
THEN RETURN	GOSUB 470:IF F
100:NEXT C:GOTO 70	0=1THEN 250
120: PAUSE "NEXT OP	240:GOSUB 390:IF F
	0=2THEN 210
TION (Help)?":	
CØ\$="123456789	250:F1=1:F2=1:1F G
AH":GOSUB 70:	1\$=G2\$THEN 300
PAUSE " "	260: IF P(1, 1)=P(1,
130:0N CGOSUB 910,	2)AND L(1,1)=L
950, 1010, 1040,	(1, 2) THEN 310
1090, 990, 1200,	270:F2=-1:IF P(1,1
190, 1320, 530, 1)=P(2,2)AND L(
40:GOTO 120	1, 1) = L(2, 2)
70.0010 120	THEN 310
	IHEN 310



```
280:F1=-1:1F P(2,1
                          440: RETURN
    )=P(2, 2)AND L(
                          450:N8=N8+1:1F N84
                              =N9THEN 488
    2, 1) = L(2, 2)
                          460: PAUSL 1$; 15
    THEN 310
                              NOT CATALOGED
290:F2=1:IF P(2,1)
                              :F0=2:RETURN
    =P(1, 2)AND L(2)
                          470: FOR 1=110 NO:
    , 1)=L(1, 2)THEN
                              IF W$(I)=B$
    310
300: PRINT "ERROR:
                              THEN 490
                          480: NEXT 1: F0=2:
    NO TRIPLET. :
                              RETURN
    COTO 198
310:FOR 1=1TO 2:P1
                          490. IF NEITHEN LET
                              Cis=1s:Cs.1)-1
    =P(1, 1):L1=L(1
    .1):P2=P(2,I):
                          500:15 NERTHEN LET
    12=1(2,)
                              02$=1$:0$(2)=1
320: PAUSE 'Work ing
    ':GOSUP 330:
                          510: D(N)=29:11: X=R
    NEXT 1:0(1)=0:
                              rknes (FR):
    G(2)=0:RETURN
                              COSUB :270:9 :
338: COSUB 650: B(1)
                              , N)=X:[([, N)=R
    =50:2(1,D=21:
                              DADEG (L0)
    Z(2, 1) = Z2
                          520:X≒RD*DEG (P1/1
340:7=21282.3593*5
                              าว:00SUB 1270.
350: IF T>=532THEN
                              P(2, N) = X: L(2, N
    COSUR 50
                              >≈RD*DEG (L1()
368: IF T<537THEN
                              YOUR ETURN
    COSUP 60
                          538: PAUSE : END
                         548: REM DIR SOLN
370: "(1)="+F):
                          558:28=SIN (21):29
    RETURN
                              =005 (21):P8-
388: L=LEN (1$): A$=
                              SIN (P!):P9=
    LEFT$ (1$, L-1)
                              COS (P1): M=-28
    :B$=RIGHT$ (]$
                              *P9:C1=C0*M:C2
    ,1):B≈ASC (B$)
    :B$=CHR$ (B-32
                              = C0*(1-M*M)/4
                          560:D=(1-C2)*(1-C2
    *(B>90)):
    RETURN
                              -C1*M):P=C2*(1
390: N8=1: RESTORE
                              +C1*M/2)/D:N=P
400: READ 19$, NO, PO
                              9*29
    , L0
                          570: YY=N: XX=P8:
410: FOR I=1TO NO:
                              COSUB 1260:51=
                              AN: D0=S0/D: U=2
    READ W$(1), D9(
     D, PI(D, LI(D))
                              *(S1-D0):W=1-2
                              *F*COS (U):U=
     : NEXT I
                              COS (U+D0)
420: IF 19$<>A$THEN
    450
430:GOSUB 470:1F F
    0=2THEN 460
```

```
580: Y=C2*C2*SIN (D
                         700:D2=C0*C0*(N1-N
    0)*COS (D0*(2*
                              2+N3)/64:D1=C0
    U*U-1>>: Y=2*P*
                              *(T*X-Y)/4;50=
    U*W*SIN (D0)
                              (T-D1+D2)*SIN
590:S2=D0+X-Y:S8=
                              (00)
    SIN (S2):S9=
                         710: M=32*T-(20*T-A
    COS (S2): k=SQR
                              )*X-(B+4)*Y
    (M*M+(N*S9-P8*
                          720:F=Y+Y-E*(4-X):
    S8)^2)
                              G=C0*(T/2+C0*M
600:P2=ATN ((P8*S9
                              /64):Q=-F*G*
    +N*S8)/K)
                              TAN (L3)/4
610:YY=-S8*Z8:XX=P
                          730:L4=(L3+Q)/2:L8
    9*S9-P8*S8*29;
                              =SIN (L4):L9=
    COSUB 1260:S3=
                              005 (14)
    AN
                          748: YY=P6*L9: XX=P9
620:H=C1*(1-C2)*S2
                              *L8:COSUB 1262
    -C1*C2*S8*COS
                              : T1=AN: Y1=-P7X
    (S1+S1-S2); L2=
                              _9.XX=P8*<u>_8</u>;
    L1+S3~H
                              COSUB 1260: T2=
630: YY=-M: XX=-(N*S
                              AN
    9-P8*S8):GOSJB
                         750:M=P1 +P1 :X=T1
    1260: Z2=AN:
                              +T2:COSUB 1258
    RETURN
                              : 21=X: X=T1-T2:
640: REM REU SOLN
                              COSUB :250:72=
650:L3=L2-L1:P3=(P
                              X: RETURN
    2-P1)/2:P4=(P1
                         760:REM FIXING RO
    +P2)/2
                              UTINE
660:P6=SIN (P3):P7
                         770:A1=F1*SIN (A(1
    =008 (P3):P8=
                              >>:B1=008 (A()
    SIN (P4): P9=
                              ))-COS (B(1));
    COS (P4)
                              C1=SIN (B(1))
620: H=P2*P2-P8*P8:
                         780:A2=F2*SIN (A(2
    L=P6*P6+H*SIN
                              )):B2=COS (A(2
    (L3/2)^2:D0=2*
                              ))-COS (B(2)):
    ASN (SQR (L))
                              C2=SIN (B(2))
680:U=2*P8*P8*P7*P
                         790:E1=Z(1,1):IF F
    フノ(1-L):U=2*P6
                              1=-1THEN LET E
    *P6*P9*P9/L: X=
                              1=Z(2,1)
    U+U: Y=U-U: T=D0
                         800:E2=Z(1,2):IF F
    /SIN (D0):D=4*
                              2=-1THEN LET E
    T*T
                              2=Z(2, 2)
690:E=2*COS (D0):A
                         810:C=B1*C2*COS (E
    =D*E:C=T-(A-E)
                              2)-B2*C1*C0S (
    /2:N1=X*(A+C*X
                              E1):S=B1*C2*
    ):B=D+D:N2=Y*(
                              SIN (E2)-B2*C1
    B+E*Y): N3=D*X*
                              *SIN (E1)
```

```
948:4(1)4A/21295.8
736:NEXT 14
828:k=B2*A1-B1*A2.
    R=SQR (C*C+S*S
    1:YY=3:XX=0:
                               COSUB 778:
    COSUB 1260: G=A
                               RETURN
                          950: IF A0=1THEN
830: 7=G+A0*ACS (k/
                               LET A0=-1:6010
    R):YY=B2:XX=C2
                               970
    *COS (Z-E2)+A2
                          960:40-1
    :GOSUB 1260:S0
                          970:GOSJB 220:
    =AN
                               RETURN
840: IF F2=1THEN
                          980:REM OPT 6
990:INPUT FORICIN
    LET P1=P(1,2):
                               LAT dd.mmss
    L1=L(1,2)
858: IF F2=-1THEN
                               15:1NF(T 05:10
    LET PIER(2,2);
                              15 1650 dag. mr
    Li=L(2,2)
860:71≈7:COSUR 550
                           1888:X=RDXDES --
                               ์ : JOSUB ไม้ W.
    :P0=P2:L0=L2:F
    =AIN (TAN (P0)
                                 #1,7=55 : (커크딩파
    /(1-C0))
                                 DEG (L):
820:P=P/RD:X=L0/RD
                                 :8181 EU2CD
    : M=360: COSUB :
                                 COSUB 1048:
    250:L=X:IF L>1
                                 RETURN
    80THEN LET L=L
                           1010. INPUT "DETT
    -360
                                 LAT dd.mmss
880: X=P: GOSUB 1280
                                  TURM: 19:
    :P$=($: X=L.
                                 DEST LINE dd
003UP 1288
898:FRINT TLA
                                 d.mms:
                           1828: Y-KD*FED
    .P$:PRINT 'LON
                                 :gosuF 1278.
    C = ';C$:
                                 PSEK: LSERDX
    RETURN
                                 DEG (L):
900: REM OPT :
                                 RETURN
910:GOSUB 185:FOR
                           1030:REM OPT 4
    I = 1 TO 2
                           1040:P1=P0:L1=L0:
920: PAUSE 'ITD FOR
                                 P2=P5:L2=L5:
     ';G$(1);:
                                 GOSUB 650
    INPUT "? ";A;
                           1050:M=360:X=Z1/R
    PAUSE : PAUSE "
                                 D: GOSUB 1250
     ":A=A+G(1)~D(
                                 :GOSUB :280
    D-T(D: IF ABS
                           1060: PRINT "HEAD!
    (A) < T(I) THEN 9
                                 NG = "; C$: M=
    40
                                 100:X=3443.9
930: PRINT "ITD NOT
                                 17*SØ:GOSUB
     VALID FOR ":G
                                 40: PRINT 'DI
                                 STANCE = ';X
    $(1):GOTO 920
                           1070: RETURN
```

```
1210: PAUSE "ITD :
1080:REM OPT 5
                               OR '; G$(K);;
1090:GOSUB 185:
                               INPUT "? ".I
     GOSUB 1170:
                              9: PAUSE :
     FOR k=1TO 2:
                              PAUSE 1 : 19
     19=T(K)+D(K)
                              =19-D(k)
1100:P2=P(2,K):L2
                         1220:P2=P(2,K).L2
     =L(2, k):
                              =L(2,K):
     GOSUB 650:1=
                               GOSUB 650: 15
     3; GOSUR 340:
                               3:COSU2 342:
     19=19+1(3)
                               19=19-1(3)
1:10:P2=P(1,K):L2
                          :230:P2=P(1.K).L2
     s1(1,k);
                               =L(1,K):
     COSUB 650:1=
                               COSUP 658.11
     %:00SUE 34€:
                               9.6030= 346.
     19-19-1(3)
                               T(K)=19+1131
1128:M-100:X-19.
                              48(K)
     GOSUB 40
1130: PRINT '1TD F
                         1248: NEXT K:
                               RETURN
     OR 1:G$(K);
                         1250: X=X-M*INT ()
      -':X:PAUSE
                               /M): RETURN
      " : NEXT K
                         1260: AN=ATN (YY)
1148: PAUSE 'New !
                               XX+1E-3* XY=
     at/long on R
                               0)))+F1 * %*
     etunn to men
                               (0): RETURN
     JA : EB$ : 'NR'
                          1270: X=ATN (()-58
     . COSUP 78
1158: 15 E-17HEN 1
                               DATAN (M.J.
                               RETURN
     pgy
                          :280:1$=1 -: 15 Y
IIBEKRÎTURN
                               BIHEN LET CE
:: 28: NPUT "LA" d
                               =1-1:X=-X
     d.mm.ss ? : :
                          1290:X=X+1/7200:X
      INPUT 'LON
                               0=1NT (X):[$
     C ddd.mmss?
                               =C$+STR$ (X2
      ;Li:PAUSE "
                               )+"
                          1300:X=60*(X-X0):
1180:X=RD*DEG (PI
                               X0=INT (X):X
     ):GOSUB 1270
                               $=STR$ (100+
     :P1=X:L1=RD*
                               XØ): C$-C$+
     DEG (L1):
                               RIGHT$ (X$, 2
     RETURN
                               )+" "
1190:REM OPT 7
                          1310:X=60*(X-X0);
:200:GOSUB 185:
                               X0=INT (X):X
     GOSUB 1170:
                               $=STR$ (100+
     FOR K=1TO 2
                               X0):[$=[$+
                               RIGHT$ (X$, 2
                               )+" '; RETURN
```

```
1320:005UB 105:
PAUS<sub>E 1</sub>ASC F
                           5020: DATA 11 .028
                                 08, 47, 834793
     OR ':G$(1).
INPUT ': :6
                                 . 119.443953.
                                 771,41000,50
                                 .3629731.10
     (1): PAUSE :
PAUSE 1 2.23840
1330: PAUSE 1451 F 5000: DATA 79301.
                                 2129043
                                3,59.591707.
     OR ":6$ 2"...
INPUT 19 ...
                                 45.182747. W
                                 11988,64.5
      (2):FAUSE /
                                 42658, 23, 55.
     PAUSE 1.
                                 : 75
RETURN
Bada.DATA (4998).
                         513. ATA TYLL 213
24.61. 175462
      9, 18, 444 235 .
                                 71.43000.46.
      .
169.3031.
      1,170,20
                                 463218, 53.12
      44916,15.15
     292
                                 2816
                           1.1881.14T4 x 1937
Selv.Dafa Probabili
                                . 3. 24. 1787 de
      ดอ. 22.734177
                                 8. -163.52531
32. Y. 11488
     .:28.:7382
1220: PATA 15937 .
                                 . 42.443 โทล์เ
     7,46,482 144
                                 -143.430924°
                           1118:54TA N. 320
      XIIIII BBN 41
                                 яв, 26. 3624°°
       15:13:.5:.5
                                 5.-128.08964
     89989
ક્સપ્રસાર કેવામાં જાતા હતા.
                                 45. 1 . 49827
                                 .9.324078.A
     Be, at . 463.1.6
                                 138.895491
     . 53.10281t
                          5128. NATA 179681.
5842:04TA 15928 .
      3, 36, 1105292
                                 2,63.1942814
                                 ,142.48313.
     .-129.202727
                                 X", 11000, 57.
      9, W, 11000,
                                 262021, 152.2
      42.4437104, -
                                 211225
      143.4309245
                          5130:DATA "Y",260
5050:DATA 'X',310
     00, 35.022387
                                 00, 55.262085
                                 1, 131.151964
      1, -126.32267
     4, 121, 42000,
                                 8
                           5140:DATA "7970",
      26.3624975+
                                4,62.125964,
      128.0856445
                                 7.0426538, W
5060:DATA '5990'.
3,51.575878,
                                 1, 26000, 54.4
                                 829872, -8.17
      122.220224,
                                 36312
      X', 11000, 55.
      2620851, 131.
      1519648
```

```
5150: DATA "X", 110
                           5230: DATA "Y", 280
     00,68.380615
                                00, 42, 425060
     ,-14.2747,
                                3, 76, 4933802
      , 46000, 64.5
                                 "Y', 44000, 4
     42658, 23.552
                                8.3649844,94
     125
                                .3318469
5160: DATA "Z", 600
                           5240: DATA "9940",
     00, 70.545261
                                3, 39.3306621
     8.435869
                                .118.495637.
5178: DATA 179881.
                                 'W', 11000, 47
     4,30.593824.
                                .034799, 119.
     85.1009305
                                443953
     W', 11000, 30.
                           5250: DATA 1X1, 278
     4333818,98.4
                                02, 32, 46599,
     9438
                                 122.2944529.
5:80:0ATA 'X',238
                                 Y 40000, 35
     00, 26.315500
                                . 191818, 114.
     6,97.5000093
                                48:7435
       "Y", 43000, 2
                           5270: DATA 198621.
     7,0158393,88
                                4, 42, 4250603
      . 0653429
                                ,76.4933862,
5198:DATA "Z",590
                                 W, 11000,45
.4827199,62.
     00, 34.034608
      1,77.5446654
                                5532713
5200:DATA 179901.
                           5280: DATA Y' , 250
     3, 38, 5220587
                                03,41.151193
     .-16.4306159
                                .69.583909,
     . Y' . 11000, 3
                                Y ,33000,34.
     5.3120787.-1
                                $346881. `
      2.3130245
                                446654
5210:DATA 'Y', 290
                           5298: DATA 171,548
     00,40.582095
                                00, 39, 510754
     .-27.520152,
                                .87.291214
      2", 47000, 42
                           5300: DATA '9970'.
      .0336515, -3.
                                4, 24, 4803597
      1215512
                                .-141.193030
5220:DATA "8970",
                                3, 'W', 11000,
      3, 39.510254,
                                24.1202888, -
     87.291214, "W
                                153.5853232
      ", 11000, 30.5
     93874, 85.100
     9305
```

PC-1500 (TRS-80 PC-2) PROGRAM LISTING (cont.)

5310: DATA "X", 300 00, 42. 443710 4, -143.43092 45, "Y", 55000 , 26. 3624975, -128.0856445 5320: DATA "Z", 750 00, 9.3245289 .-138.095497 5330: DATA '9990'. 3,57.091265, 170.1506789, "X", 11000, 52 .494404, -173 .1048974 5340: DATA "Y", 290 00, 65. 144030 6, 166.531255 , 2', 43000, 5 2.262021, 152 .2211225

IV. THE RADIO SHACK TRS-80 MODEL 100.

TRS-80 MODEL 100 USER INSTRUCTIONS.

The options are labeled 1 through 9 or A. Option 6 (TWO POINT HEAD & DIST) is a stand-alone option which may be used by itself. For LORAN fixing, Option 8 must be selected first to load the station GRI's. If Option 8 is not used, then any option requiring the GRI's will automatically enter Option 8 first. Option 1 (LORAN FIX) must be selected at least once before Option 2 (ALTERNATE SOLN) can be selected. Once the GRI's are loaded, any of the remaining options may be used at any time. When first run, the ASF Correction Factors are set to zero; if they are subsequently entered as non-zero values they will remain set until either changed manually, by selection of Option 9, or until the program is RUN once more. In all cases, South latitudes and East longitudes must be negative for input and will be labeled by a minus sign '-' on output. For ease of reference the options are listed by number rather than by sequence of selection.

INSTRUCTION	DISPLAY	INPUT
Run Program	Select LORAN.BA	[ENTER]
	OPTION?	_
1. LORAN FIX ITD for 1st G ITD for 2nd G Lat of fix Long of fix	RI ITD FOR <u>gri 2</u> ? LAT = dd°mm'ss"	lst ITD [ENTER] 2nd ITD [ENTER] [ENTER] [ENTER]
2. ALTERNATE SOL		2
Lat of fix Long of fix	and the second s	[ENTER] [ENTER]
3. INPUT DEST LA	T/LONG	3
	DEST LAT dd.mmss?	Lat of dest. [ENTER]
	DEST LONG ddd.mmss?	
	OPTION?	
4. HEAD & DIST T Heading to de Dist. to dest	st. HEADING = ddomm'ss"	

TRS-80 MODEL 100 USER INSTRUCTIONS (cont.)

	INSTRUCTION	DISPLAY	INPUT
5.	PREDICT ITDs	LAT dd.mmss?	5 Lat [ENTER]
	lak rmb	LONG ddd.mmss? ITD FOR gri 1 =	Long [ENTER]
	lst ITD	xxxxx.xx µs	[ENTER]
	2nd ITD	ITD FOR <u>gri 2</u> = xxxxx.xx μs	[ENTER]
		New Lat/Lon or Return to menu	N repeats Option 5 R goes to next line
		OPTION?	your to none 11me
6.	TWO POINT HEAD & DIS	ST	6
		ORIGIN LAT dd.mmss?	Lat of origin [ENTER]
		ORIGIN LONG ddd.mmss?	Long of origin [ENTER]
		DEST LAT dd.mmss?	Lat of dest. [ENTER]
		DEST LONG ddd.mmss?	Long of dest. [ENTER]
	Heading to dest. Dist. to dest.	<pre>HEADING = ddomm'ss" DISTANCE = mmm.ff n.mi OPTION?</pre>	[ENTER]
7.	CALIBRATE		7
		LAT dd.mmss?	Lat of fix [ENTER]
		LONG ddd.mmss? ITD FOR <u>gri 1</u> ?	Long of fix [ENTER] 1st ITD [ENTER]
		ITD FOR GIL 1? ITD FOR GIL 2? OPTION?	2nd ITD [ENTER]
8.	NEW STA. IDs		8
		lst GRI? 2nd GRI? OPTION?	Sta. ID [ENTER] Sta. ID [ENTER]
٥	ASF Corrections		9
7.	ASF COLLECTIONS	ASF FOR gri 1? ASF FOR gri 2? OPTION?	lst ASF [ENTER] 2nd ASF [ENTER]
A.	STOP		A

>

TRS-80 MODEL 100 SAMPLE PROBLEM 1

You are sailing off of the coast of California. Your destination is Moss Landing at about 36°48'N and 121°47'W. Your present ITD from station pair GRI 9940W is 16019 and your ITD from station pair GRI 9940Y is 42585. What is your current position and what is the heading and distance from your current position to Moss Landing? We assume that the GRI's 9940W and 9940Y have not yet been loaded.

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
OPTION? DEST LAT dd.mmss? DEST LONG ddd.mmss?	3 36.48 [ENTER] 121.47 [ENTER]	Input destination. 36°48' 121°47'
OPTION? 1st GRI? 2nd GRI?	8 9940W [ENTER] 9940Y [ENTER]	Input station ID's.
OPTION? ITD FOR 9940W? ITD FOR 9940Y?	1 16019 42585	Compute a fix.
LAT = 39°14'19" LONG = 115°50'52"		Latitude of fix. Longitude of fix.

This fix is in Nevada. There are always two solutions to the LORAN equations. The navigator must select the correct one.

OPTION?	2	Select alternate soln.
LAT = 35°00'01" LONG = 125°00'09"	[ENTER] [ENTER]	Latitude of fix. Longitude of fix.
DONG - 123 00 03	[ENIEK]	nongitude of lix.

This fix is in the Pacific. The navigator knows it is the correct fix because of his estimate of where he should be.

OPTION?	4	Find heading & distance to destination.
HEADING = 54°34'11" DISTANCE = 190.38 n.mi.	[ENTER]	Heading to Moss Landing. Distance to Moss Landing.

OPTION?

Repeat with new option or press A to quit.

TRS-80 MODEL SAMPLE PROBLEM 2

How far, and in what direction, is Corvallis, Oregon (44°34'N, 123°16'W) from Cupertino, California (37°19'N, 122°02'W)?

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
OPTION?	6	Two point distance and heading.
ORIGIN LAT dd.mmss?	37.19 [ENTER]	37° 19'
ORIGIN LONG ddd.mmss?	122.02 [ENTER]	122° Ø2 '
DEST LAT dd.mmss?	44.34 [ENTER]	44° 34 '
DEST LONG ddd.mmss?	123.16 [ENTER]	123°16'
$HEADING = 353^{\circ} 02'59"$	[ENTER]	
DISTANCE = 438.32 n.mi.	[ENTER]	

OPTION?

Repeat with new option or press A to quit.

TRS-80 MODEL SAMPLE PROBLEM 3

Suppose that you want to know what ITD's you would expect to receive at 35° North, 125° West and at 36°27' North, 126°54' West from 9940W and 9940Y. To determine these ITD's, proceed as follows (assume that the GRI's have been loaded as in Sample Problem 1):

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
OPTION? LAT dd.mmss?	5 35 [ENTER]	Predict ITD's. 35°
LONG ddd.mmss?	125 [ENTER]	125°
ITD FOR $9940W = 16019.35$	[ENTER]	
ITD FOR $9940Y = 42584.71$	[ENTER]	
New Lat/Lon or		
Return to menu?	N	
LAT dd.mmss?	36.27 [ENTER]	36°27'
LONG ddd.mmss?	126.54 [ENTER]	126°54'
ITD FOR $9940W = 15572.32$	[ENTER!	
ITD FOR $9940Y = 43006.15$	[ENTER]	
New Lat/Lon or	-	
Return to menu?	R	

OPTION?

Repeat with new option or press A to quit.

TRS-80 MODEL 100 SAMPLE PROBLEM 4

Suppose you are receiving an ITD of 16308 from 9940W and 42800 from 9940Y. These ITD's would tell you that your location is 36°47'55"N and 121°47'11"W. However, you know that your position is benchmarked to be at 36°47'36"N and 121°46'58"W, and you wish to calibrate your Model 100 so that the ITD's of 16308 and 42800 will give you the latter fix instead of the former. Proceed as follows (assume the GRI's have been loaded as in Sample Problem 1):

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
OPTION?	7	Calibrate.
LAT dd.mmss?	36.4736 [ENTER]	36°47'36"
LONG ddd.mmss?	121.4658 [ENTER]	121°45'58"
ITD FOR 9940W?	16308 [ENTER]	
ITD FOR 9940Y?	42800 [ENTER]	

The station baselines have now been modified to achieve calibration. Now, reenter 16038 and 42800 into the fixing routine to test the calibration. Calibration does not modify the permanent station data stored in the Model 100. The calibration remains effective until the GRI's are reloaded by Option 8. NOTE: The affect of calibration on the accuracy of fixes far removed from the benchmark has not been studied. The user should use the calibration option with caution.

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
OPTION? ITD FOR 9940W? ITD FOR 9940Y?	l 16308 [ENTER] 42800 [ENTER]	Compute a fix.
LAT = 36°47'35" LONG = 121°46'59"	[ENTER] [ENTER]	Lat of fix. Long of fix.

The small discrepancy between this fix and the benchmark is due to assumptions in the fixing algorithm. If higher precision is required, the ASF Correction factor may be used (see Sample Problem 5). Note that you may need to use the Alternate Solution Option 2 if the fix obtained above is near 38°52'57"N and 116°51'11'W.

DISPLAY	CONTENTS	USER	RESPONSE	COMMENTS

OPTION? Repeat with new option or press A to quit.

TRS-80 MODEL 100 SAMPLE PROBLEM 5

Suppose you are receiving an ITD of 12153.31 microseconds from 9960W and 44451.83 microseconds from 9960W. These ITD's would tell you that your location is 44°15'05"N and 67°25'23"W. Entering the ASF Correction Tables [Ref. 5,6] with these readings, the ASF Correction for GRI 9960W at 44°15'N and 67°25'W is 1.5 microseconds. Similiarly, the ASF Correction for GRI 9960Y at these coordinates is 2.7 microseconds. Enter these corrections into your Model 100 and recompute your position. (Load the GRI's 9960W and 9960Y using Option 8).

DISPLAY CONTENTS	USER RESPONSE	COMMENTS
OPTION? ASF FOR 9960W? ASF FOR 9960Y?	9 1.5 [ENTER] 2.7 [ENTER]	ASF Correction.
OPTION? ITD FOR 9960W? ITD FOR 9940Y? LAT = 44°15'26"	1 12153.31 [ENTER] 44451.83 [ENTER] [ENTER]	Compute a fix.
LAT = 44 15 26 LONG = 67°26'26" OPTION?	[ENTER]	Repeat with new option or press A to quit.

These ASF Corrections have been entered into the computer. The range of their validity must be checked with the ASF Correction tables and reentered if they change. NOTE: If you are using the ASF Correction Tables and if you wish to calibrate to a benchmark position, you should first enter the ASF Corrections for your benchmark and then use the calibration Option 7 (see Sample Problem 4).

TRS-80 MODEL 100 PROGRAM LISTING

```
10 REM LORAN-C ROUTINE. REV 07-15-83. 1530 HOURS
20 N9=15:REM N9 = NO. OF MASTER STATIONS
30 C0=1/298.26:A0=-1:PI=4.*ATN(1):TP=PI+PI:RD=PI/180:G$(1)
="":GOTO120
32 FORC=1TO9:C$=INKEY$:NEXTC
33 PRINT:PRINT"Press any key to continue."
34 C$=INKEY$:IFC$=""GOTO34"
35 RETURN
40 X=INT(M0*X+.5)/M0:RETURN
50 P=129.04398/T-.40758+.645765438E-3*T:RETURN
60 P=2.7412979/T~.32774624-3*T:RETURN
70 C$=INKEY$:IFC$=""GOTO70
80 C=ASC(C\$):C\$=CHR\$(C+32*(C>90))
90 FORC=1TOLEN(CO$): IFC$=MID$(CO$, C, 1) THENRETURN
100 NEXTC:GOTO70
120 CLS:PRINT"1-LORAN FIX
                                  6-TWO PT HEAD & DIST"
130 PRINT"2-ALT. SOLUTION
                              7-CALIBRATE"
                              8-NEW STA. IDs "
140 PRINT"3-DEST LAT/LON
                              9-ASF Correction"
150 PRINT"4-HEAD & DIST
160 PRINT"5-PREDICT ITDs
                              A-STOP
170 PRINT: PRINT"OPTION?": C0$="123456789A": GOSUB70
180
CLS:ONCGOSUB910,950,1010,1040,1090,990,1200,190,1320,530:GOTO120
185 IFG1$<>""THENRETURN
190 F0=1:N=1:CLS:INPUT"1st GRI"; I$
200 GOSUB380:GOSUB390:IFF0=2GOTO190
210 F0=1:N=2:INPUT"2nd GRI"; I$:GOSUB380
220 IFA$=19$THENGOSUB470:IFF0=1GOTO250
240 GOSUB390:IFF0=2GOTO210
250 F1=1:F2=1:IFG1$=G2$GOTO300
260 IFP(1,1)=P(1,2)ANDL(1,1)+L(1,2)GOTO310
270 F2=-1:IFP(1,1)=P(2,2)ANDL(1,1)+L(2,2)GOTO310
280 F1=-1:IFP(2,1)=P(2,2)ANDL(2,1)+L(2,2)GOTO310
290 F2=2:IFP(2,1)=P(1,2)ANDL(2,1)+L(1,2)GOTO310
300 PRINT"ERROR: NO TRIPLET. ":GOSUB32:GOTO190
310 PRINT:PRINT"Working":FORI=1TO2:Pl=P(1,I):L1=L(1,I):P2=P(2,I)
:L2=L(2,I)
320 GOSUB330:NEXTI:G(1)=0:G(2)=0:RETURN
330 GOSUB650:B(I)=S0:Z(1,I)=Z1:Z(2,I)=Z2
340 T=21282.3593*S0
350 IFT>=537THENGOSUB50
360 IFT<537THENGOSUB60
370 \text{ T(I)} = \text{T+P:RETURN}
380 L=LEN(I$):A$=LEFT$(I$,L-1):B$=RIGHT$(I$,1):B=ASC(B$):B$=CHR$(
B+32*(B>90)):RETURN
390 N8=1:RESTORE
400 READI9$, NO, PO, LO
410 FORI=1TON0:READW$(I),D9(I),P1(I),L1(I):NEXTI
420 IFI9$<>A$GOTO450
430 GOSUB470:IFF0=2GOTO460
440 RETURN
```

```
450 N8=N8+1:IFN8<=N9GOTO400
460 PRINTIS; " IS NOT CATALOGED":F0=2:GOSUB32:RETURN
470 FORI=1TON0: IFW$(I)=B$GOTO490
480 NEXTI:FØ=2:RETURN
490 IFN=1THENG1\$=1\$:G\$(1)=1\$
500 IFN=2THENG2\$=I\$:G\$(2)=I\$
510 D(N) = D9(I) : X = P0 : GOSUB1370 : P(1, N) = X : X = L0 : GOSUB1360 : L(1, N) = V*RD
520 \times P1(I):GOSUB1370:P(2,N)=X:X=L1(I):GOSUB1360:L(2,N)=V*
RD: RETURN
530 END
540 REM DIRECT SOLUTION
550 Z8=SIN(Z1):Z9=COS(Z1):P8=SIN(P1):P9=COS(P1):M=-Z8*P9:C1=C0*
M:C2=C0*(1-M*M)/4
560 D = (1-C2)*(1-C2-C1*M): P=C2*(1+C1*M/2)/D:N=P9*Z9
570 \text{ YY} = \text{N}: XX = P8: GOSUB1260: S1 = AN: D0 = S0/D: U = 2*(S1 - D0): W = 1 - 2*P*COS(U)
:V=COS(U+DØ)
580 \text{ X} = \text{C2} \times \text{C2} \times \text{SIN}(D0) \times \text{COS}(D0 \times (2 \times V \times V - 1)) : Y = 2 \times P \times V \times W \times \text{SIN}(D0)
590 S2 = D0 + X - Y : S8 = SIN(S2) : S9 = COS(S2) : K = SQR(M*M + (N*S9 - P8*S8)^2)
600 \text{ P2} = \text{ATN}((P8 * S9 + N * S8) / K)
610 YY=-S8*Z8:XX=P9*S9-P8*S8*Z9:GOSUB1260:S3=AN
620 \text{ H} = \text{C1} * (1-\text{C2}) *\text{S2} - \text{C1} * \text{C2} * \text{S8} * \text{COS} (\text{S1} + \text{S1} - \text{S2}) : \text{L2} = \text{L1} + \text{S3} - \text{H}
630 YY=-M:XX=-(N*S9-P8*S8):GOSUB1260:Z2=AN:RETURN
640 REM REVERSE SOLN
650 L3=L2-L1:P3=(P2-P1)/2:P4=(P1+P2)/2
660 P6=SIN(P3):P7=COS(P3):P8=SIN(P4):P9=COS(P4)
670 \text{ H} = \text{P7} + \text{P7} - \text{P8} + \text{P8} : \text{L} = \text{P6} + \text{P6} + \text{H} + \text{SIN}(\text{L3}/2)^2 : XX = SQR(L) : GOSUB1340 : D0 = 2*
AN
680 \text{ U} = 2*P8*P8*P7*P7/(1-L):V=2*P6*P6*P9*P9/L:X=U+V:Y=U-V:T=D0/SIN(
D0):D=4*T*T
690 = 2 \times COS(D0) : A = D \times E : C = T - (A - E) / 2 : N1 = X \times (A + C \times X) : B = D + D : N2 = Y \times (B + E \times Y)
:N3=D*X*Y
700 D2=C0*C0*(N1-N2+N3)/64:D1=C0*(T*X-Y)/4:S0=(T-D1+D2)*SIN(D0)
710 M=32*T-(20*T-A)*X-(B+4)*Y
720 F=Y+Y-E*(4-X):G=C0*(T/2+C0*M/64):Q=-F*G*TAN(L3)/4
730 L4 = (L3 + Q)/2:L8 = SIN(L4):L9 = COS(L4)
740 YY=P6*L9:XX=P9*L8:GOSUB1260:T1=AN:YY=-P7*L9:XX=P8*
L8:GOSUB1260:T2=AN
750 M0=TP:X=T1+T2:GOSUB1250:Z1=X:X=T1-T2:GOSUB1250:Z2=X:RETURN
760 REM FIXING ROUTINE
770 \text{ Al} = \text{Fl} * \text{SIN}(A(1)) : \text{Bl} = \text{COS}(A(1)) - \text{COS}(B(1)) : \text{Cl} = \text{SIN}(B(1))
780 A2=F2*SIN(A(2)):B2=COS(A(2))-COS(B(2)):C2=SIN(B(2))
790 E1=Z(1,1): IFF1=-1THENE1=Z(2,1)
800 \text{ E2} = 2(1,2) : \text{IFF2} = -1\text{THENE2} = 2(2,2)
810 C=B1*C2*COS(E2)-B2*C1*COS(E1):S=B1*C2*SIN(E2)-B2*C1*SIN(E1)
820 K=B2*A1-B1*A2:R=SQR(C*C+S*S):YY=S:XX=C:GOSUB1260:G=AN
830 XX=K/R:GOSUB1350:Z=G+A0*AN:YY=B2:XX=C2*COS(Z-E2)+
A2:GOSUB1260:S0=AN
840 IFF2=1THENP1=P(1,2):L1=L(1,2)
850 IFF2=-1THENP1=P(2,2):L1=L(2,2)
860 Z1=Z:GOSUB550:P0=P2:L0=L2:P=ATN(TAN(P0)/(1-C0))
```

```
870 P=P/RD:X=L0/RD:M0=360:GOSUB1250:L=X:IFL>180THENL=L-360
880 X=P:GOSUB1280:P$=C$:X=L:GOSUB1280
890 PRINT:PRINT"LAT = ":PS:PRINT"LONG = ":CS:RETURN
900 REM OPT 1
910 GOSUB185:CLS:FORI=1TO2
920 PRINT"ITD FOR ";G$(I);:INPUTA:A=A+G(I)-D(I)-T(I):IFABS(A)<T(I)
GOTG940
930 PRINT"ITD NOT VALID FOR ";G$(I):GOSUB32:GOTO920
940 A(I)=A/21295.8736:NEXTI:GOSUB770:GOSUB32:RETURN
945 REM OPT 2
950 IFA0=1THENA0=-1:GOTO970
960 A0 = 1
970 GOSUB770:GOSUB32:RETURN
980 REM OPT 6
990 CLS:INPUT"ORIGIN LAT
                           dd.mmss":P:INPUT"ORIGIN LONG
ddd.mmss";L
1000 X=P:GOSUB1370:P0=X:X=L:GOSUB1360:L0=V*
RD:GOSUB1010:GOSUB1040:RETURN
1010 CLS:INPUT"DEST LAT dd.mmss";P:INPUT"DEST LONG ddd.mmss";L
1020 X=P:GOSUB1370:P5=X:X=L:GOSUB1360:L5=V*RD:RETURN
1030 REM OPT 4
1040 P1=P0:L1=L0:P2=P5:L2=L5:GOSUB650
1050 M0=360:X=Z1/RD:GOSUB1250:GOSUB1280
1060 CLS:PRINT"HEADING = ";C$:M0=100:X=3443.917*
SØ:GOSUB4Ø:PRINT"DISTANCE = ";X;" n. mi."
1070 GOSUB32:RETURN
1080 REM OPT 5
1090 GOSUB185:GOSUB1170:PRINT:FORK=1TO2:I9=T(K)+D(K)
1100 P2=P(2,K):L2=L(2,K):GOSUB650:I=3:GOSUB340:I9=I9+T(3)
1110 P2=P(1,K):L2=L(1,K):GOSUB650:I=3:GOSUB340:I9=I9-T(3)
1120 M0=100:X=19:GOSUB40
1130 PRINT"ITD FOR ";G$(K);" = ";X:NEXTK
1140 PRINT:PRINT"New lat/long or Return to menu?":C0$="NR":GOSUB70
1150 IFC=1GOTO1090
1160 RETURN
1170 CLS: INPUT"LAT
                     dd.mmss"; Pl:INPUT"LONG ddd.mmss"; Ll
1180 X=P1:GOSUB1370:P1=X:X=L1:GOSUB1360:L1=V*RD:RETURN
1190 REM OPT 7
1200 GOSUB185:GOSUB1170:FORK=1TO2:I$=G1$:IFK=2THENI$=G2$
1210 CLS:PRINT"ITD FOR "; I$;:INPUT I9: I9= I9-D(K)
1220 P2=P(2,K):L2=L(2,K):GOSUB650:I=3:GOSUB340:I9=I9-T(3)
1230 P2=P(1,K):L2=L(1,K):GOSUB650:I=3:GOSUB340:T(K)=I9+T(3)+G(K)
1240 NEXTK: RETURN
1250 X=X-M0*INT(X/M0):REM MOD FCTN
1260 AN=ATN(YY/(XX-1E-9*(XX=0)))-PI*(XX<0):RETURN:REM QATN
1270 X=ATN((1-C0)*TAN(X)):RETURN
1280 CS=" ":IFX<0THENCS="-":X=-X
1290 X=X+1/7200:X0=INT(X):C$=C$+STR$(X0)+" "
1300 X=60*(X-X0):X0=INT(X):X$=STR$(100+X0):C$=C$+RIGHT$(X$.2)+" "
```

```
1310 X=60*(X-X0):X0=INT(X):X$=STR$(100+X0):C$=C$+RIGHT$(X$,2)+
":RETURN
1320 GOSUB185:CLS:PRINT"ASF FOR ";G$(1);:INPUTG(1)
1330 PRINT"ASF FOR ";G$(2);:INPUTG(2):RETURN
1340 ZZ=SQR(1-XX*XX):AN=ATN(XX/(ZZ-1E-9*(ZZ=0))):RETURN:REM ASIN
1350 AN=ATN(SQR(1-XX*XX)/(XX-1E-9*(XX=0)))-PI*(XX<0):RETURN:REM
ACOS
1360 S=SGN(X):X=ABS(X): H=INT(X):MØ=1:GOSUB1250:V=X*
100:X=V:GOSUB1250
1365 V=S*((100*X/60+INT(V))/60+H):RETURN
1370 GOSUB1360:X=V*RD:GOSUB1270:RETURN
5000 DATA
"4990",2,16.444395,169.30312,"X",11000,20.144916,155.53097
5010 DATA "Y", 29000, 28.234177, 178.17302
5020 DATA
"5930", 2, 46.4827199, 67.5537713, "X", 11000, 41.151193, 69.583909
5030 DATA "Y",25000,46.46463218,53.102816
5040 DATA "5970",3,36.1105797,-129.2027279,"W",11000,42.4437104,-
143.4309245
5050 DATA "X",31000,35.0223871,-126.322674,"Z",42000,263624975,-
128.0856445
5060 DATA
"5990",3,51.575878,122.220224,"X",11000,55.2620851,131.1519648
5070 DATA
"Y", 27000, 47.034799, 119.443953, "Z", 41000, 50.3629731, 127.2129043
5080 DATA
"7930",3,59.591727,45.102747,"W",11000,64.542658,23.552175
5090 DATA
"X",21000,62.175964,7.0426538,"Z",43000,46.463218,53.102816
5100 DATA "*7930",3,24.1707888,-153.5853232,"X",11000,42.4437104,-
143.4309245
5110 DATA "Y",30000,26.3624975,-128.0856445,"Z",49000,9.3245789,-
138.095497
5120 DATA
"7960",2,63.1942814,142.48319,"X",11000,57.262021,152.2211225
5130 DATA "Y", 26000, 55.2620851, 131.1519648
5140 DATA "7970",4,62.175964,7.0426538,"W",26000,54.4829872,-
8.1736312
5150 DATA "X",11000,68.380615,-
14.2747, "Y", 46000, 64.542658, 23.552175
5160 DATA "Z",60000,70.545261,8.435869
5170 DATA
"7980",4,30.593874,85.1009305,"W",11000,30.4333018,90.49436
5180 DATA
"X",23000,26.3155006,97.5000093,"Y",43000,27.0158393,80.0653429
5190 DATA "Z",59000,34.0346081,77.5446654
5200 DATA "7990",3,38.5220587,-16.4306159,"X",11000,35.3120787,-
12.3130245
```

```
5210 DATA "Y",29000,40.582095,-27.520152,"Z",47000,42.0336515,-
3.1215512
5220 DATA
"8970",3,39.510754,87.291214,"W",11000,30.593874,85.1009305
5230 DATA
"X",28000,42.4250603,76.4933862,"Y",44000,48.3649844,94.3318469
5240 DATA
"9940",3,39.3306621,118.495637,"W",11000,47.034799,119.443953
5250 DATA
"X",27000,38.465699,122.2944529,"Y",40000,35.191818,114.4817435
5270 DATA
"9960",4,42.4250603,76.4933862,"W",11000,46.4827199,67.5537713
5280 DATA
"X", 25000, 41.151193, 69.583909, "Y", 39000, 34.0346081, 77.5446654
5290 DATA "Z",54000,39.510754,87.291214
5300 DATA "9970",4,24.4803597,-141.1930303,"W",11000,24.1707888,-
153.5853232
5310 DATA "X",30000,42.4437104,-143.4309245,"Y",55000,26.3624975,-
128.0856445
5320 DATA "Z",75000,9.3245789,-138.095497
5330 DATA "9990",3,57.091265,170.1506789,"X",11000,32.494404,-
173.1048974
5340 DATA
"Y",29000,65.1440306,166.531255,"Z",43000,57.262021,152.2211225
```

V. MEMORY REQUIREMENTS

	HP-75C	PC-1500 (TRS-80 PC-2)	TRS-80 MODEL 100
Memory (bytes) for:			
Program	7747	71 89	7220
Variables	4920	?	4786
TOTAL	12667	?	12006

VI. REFERENCES

DMA

- 1. J. A. Pierce, A. A. McKenzie and R. H. Woodward, editors, LORAN, M.I.T. Radiation Laboratory Series, McGraw-Hill Book Company, Inc., 1948.
- 2. G. Hefley, The Development of Loran-C Navigation and Timing, National Bureau of Standards Monograph 129, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C. 20402, October 1972.
- 3. R. H. Shudde, "Position Determination with LORAN-C Triplets and the Hewlett-Packard HP-41CV Programmable Calculator", Technical Report NPS55-82-022, September 1982, Naval Postgraduate School, Monterey, CA 93940.
- 4. J. J. Speight, "DMAHTC Support to National Ocean Survey Loran-C Charting", NAVIGATION: Journal of The Institute of Navigation, Vol. 29, No. 1, Pg. 22, 1982.
- 5. The following tables of ASF Corrections are available from the Defense Mapping Agency Office of Distribution Services, Washington, D.C. 20315:

Stock Number	Title
LCPUB2211100C	East Coast Canada (Pairs 5930-X,Y)
LCPUB2211200C	Northeast USA (Pairs 9960-W,X,Y,Z)
LCPUB2211300C	Great Lakes (Pairs 8970-X,Y,Z)
LCPUB2211400C	Southeast USA (Pairs 7980-W,X,Y,Z)
LCPUB2212100C	West Coast of USA (Pairs 9940-W,X,Y)
LCPUB2212200C	West Coast Canada (Pairs 5990-X,Y,Z)
LCPUB2212300C	Gulf of Alaska (Pairs 7960-X,Y)

LCPUB2212400C North Pacific (Pairs 9990-X,Y,Z)

Appendix: LORAN-C STATION DATA

The following list contains the pertinent parameters for each Loran-C station pair. This list was compiled from the data in Reference 4. Each column contains the following information:

- 1. The Loran-C station pair designator.
- 2. The coding delay.
- 3. The master station latitude.
- 4. The master station longitude.
- 5. The slave station latitude.
- 6. The slave station longitude.

In this list, positive longitudes are West, negative longitudes are East, positive latitudes are North and negative latitudes are South. In columns 3 through 6 the latitudes and longitudes appear to be in decimal form, but the actual format is DDD.MMSSFFF where

DDD designates degrees,

MM designates minutes,

SS designates seconds, and

FFF designates thousandths of seconds.

LORAN-C STATIONS

GRI	CD	MS LAT	MS LON	SS LAT	SS LON
4990X	11000	16.4443950	169.3031200	20.1449160	155.5309700
4990Y	29000	16.4443950	169.3031200	28,2341770	178.1730200
593ØX	11000	46.4827199	067.5537713	41.1511930	069.5839090
593ØY	25000	46.4827199	067.5537713	46.4632180	053.1028160
5970W	11000	36.1105797	-129.2027279	42.4437104	-143.4309245
5970X	31000	36.1105797	-129.2027279	35.0223871	-126.3226741
5970Z	42000	36.1105797	-129.2027279	26.3624975	-128.0856445
599ØX	11000	51.5758780	122.2202240	55.2620851	131.1519648
599ØY	27000	51.5758780	122.2202240	47.0347990	119.4439530
5990z	41000	51.5758780	122.2202240	50.3629731	127.2129043
793ØW	11000	59.5917270	045.1027470	64.5426580	023.5521750
793ØX	21000	59.5917270	045.1027470	62.1759640	007.0426538
793Ø2	43000	59.5917270	045.1027470	46.4632180	053.1028160
*793ØX	11000	24.1707888	-153.5853232	42.4437104	-143.4309245
*793ØY	30000	24.1707888	-153.5853232	26.3624975	-128.0856445
*793ØZ	49000	24.1707888	-153.5853232	09.3245789	-138.0954970
7960X	11000	63.1942814	142.4831900	57.2620210	152.2211225
796ØY	26000	63.1942814	142.4831900	55.2620851	131.1519648
7970W	26000	62.1759640	+007.0426538	54.4829872	-008.1736312
7970X	11000	62.1759640	+007.0426538	68.3806150	-014.2747000
797ØY	46000	62.1759640	+007.0426538	64.5426580	+023.5521750
7970Z	60000	62.1759640	+007.0426539	70.5452610	+008.4358690
7980W	11000	30.5938740	085.1009305	30.4333018	090.4943600
7980X	23000	30.5938740	085.1009305	26.3155006	097.5000093
7980Y	43000	30.5938740	085.1009305	27.0158393	080.0653429
798ØZ	59000	30.5938740	085.1009305	34.0346081	077.5446654
7990X	11000	38.5220587	-016.4306159	35.3120787	-012.3130245
799ØY	29000	38.5220587	-016.4306159	40.5820950	-027.5201520
799Ø2	47000	38.5220587	-016.4306159	42.0336515	-003.1215512
897ØW	11000	39.5107540	087.2912140	30.5938740	085.1009305
897ØX	28000	39.5107540	087.2912140	42.4250603	076.4933862
897ØY	44000	39.5107540	087.2912140	48.3649844	094.3318469
9940W	11000	39.3306621	118.4956370	47.0347990	119.4439530
9940X	27000	39.3306621	118.4956370	38.4656990	122.2944529
9940Y	40000	39.3306621	118.4956370	35.1918180	114.4817435
996ØW	11000	42.4250603	076.4933862	46.4827199	067.5537713
9960X	25000	42.4250603	076.4933862	41.1511930	069.5839090
996ØY	39000	42.4250603	076.4933862	34.0346081	077.5446654
9960Z	54000	42.4250603	076.4933862	39.5107540	087.2912140
9970W	11000	24.4803597	-141.1930303	24.1707888	-153.5853232
9970X	30000	24.4803597	-141.1930303	42.4437104	-143.4309245
997ØY	55000	24.4803597	-141.1930303	26.3624975	-128.0856445
9970Z	75000	24.4803597	-141.1930303	09.3245789	-138.0954970
9990X	11000	57.0912265	+170.1506789	52.4944040	-173.1048974
999ØY	29000	57.0912265	+170.1506789	65.1440306	+166.5312550
9990z	43000	57.0912265	+170.1506789	57.2620210	+152.2211225

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